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ABSTRACT

This paper examines the academic task model used in the Managing Academic Tasks study as a potentially useful approach to some enduring problems or themes of research in science education: (1) effects of questioning and presentation strategies; (2) testing; (3) the role of laboratory activities; and (4) curriculum implementation and evaluation. The definition of academic tasks focuses attention on each of the following: the products students are required to produce; the resources, including content instruction, that are available to them; accountability or the reward structure in the class; and the cognitive demands of the tasks. Analysis of tasks in the classroom requires attention to interrelationships among tasks as well as to the actions and perceptions of students and teachers. This paper attempts to illustrate how further attention to these multiple dimensions of work systems in classrooms might shed light on some important questions in science education. (Author/JN)

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Academic Tasks and Research in Science Teaching

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Abstract

This paper examines the academic task model used in the Managing Academic Tasks study as a potentially useful approach to some enduring problems or themes of research in science education: (a) effects of questioning and presentation strategies, (b) testing, (c) the role of laboratory activities, and (d) curriculum implementation and evaluation. The definition of academic tasks focuses attention on the products students are required to produce; the resources, including content instruction, that are available to them; accountability or the reward structure in the class; and the cognitive demands of tasks. Analysis of tasks in classrooms requires attention to interrelationships among tasks as well as to the actions and perceptions of students and teachers. This paper attempts to illustrate how further attention to these multiple dimensions of work systems in classrooms might shed light on some important questions in science education.

Academic Tasks and Research in Science Teaching

Science education research and development has historically included a focus on the learner and on the intellectual demands of classroom activities. Certainly, the curriculum movement and related research of the 1960's and early 1970's focused very directly on the nature of learning experiences afforded by science lessons, and on the question of what kinds of operations students are given opportunities to practice in classroom tasks. (See, for example, Schwab, 1962 and Shulman, 1968.)

Science education research has paid much less attention, however, to the complexities of enacting these tasks in classrooms. The academic task framework proposed by Doyle (1983) encourages consideration not only of curriculum objectives, tasks, and learners but also of the peculiarities of classroom settings that shape tasks: the exigencies of classroom management, classroom and school reward systems, how students are organized for work in classrooms, and what resources they are provided. This paper examines the academic task model, which has been used as a framework for a series of studies at the Research and Development Center for Teacher Education, as a potentially useful approach to some enduring problems or themes in science education, including (a) effects of questioning and presentation strategies, (b) testing, (c) the role of laboratory activities, and (d) curriculum implementation and evaluation.

Examining Academic Tasks: The MAT

The Managing Academic Tasks (MAT) studies (Doyle, Sanford, Clements, French, & Emmer, 1983; Doyle, Sanford, Nespor, & French, in press) are built on an assumption that students encounter content in the

form of assignments for which they are held accountable. The nature of the work and how it is managed by teachers determines in large part what students attend to and how they process information, thus what skills they practice, how they are evaluated, and in the final analysis, what they learn. A task is an assignment characterized by:

1. an end product (e.g., answers in blanks on a worksheet, a written report of a laboratory experiment, a test paper, an oral report);

2. resources used in producing the product (e.g., textbook, classroom handouts, teacher explanations, prompts, and assistance, peer assistance, models and examples);

3. a set of cognitive operations required to produce the product (e.g., copy a diagram of a cell, recall definitions or terms, apply a mathematical algorithm, design an experiment, search and match);

4. a weight or expectation of weight in a classroom accountability system (e.g., a major grade, extra credit, a minor grade).

Studying academic tasks requires daily observation of a class during a unit of work. In the MAT studies, observation periods have ranged from 6 to 7 weeks. A classroom observer takes notes of all classroom events and instruction, concentrating primarily on circumstances that define the nature of students' products and the conditions under which they are produced. Such information includes teachers' introduction of and directions for assignments; resources available to students during work periods; teachers' responses to students' questions about the work; models and examples provided to students; assistance or feedback provided by the teacher while students work; statements about grading policies or accountability; and teacher

comments about relationships among different tasks. In addition, observers keep a record of class time use and a running account of classroom events focusing on such dimensions as student participation and engagement, sources and focus of student-initiated questions, work-related interaction among students, and other indications of the flow of work in the room. During teachers' explanations of tasks and content instruction, audiotapes are sometimes made. After each observation, the observer uses notes (and audiotape when available) to generate a narrative description of the class session.

Copies of all assignment sheets, worksheets, textbooks, and other instructional materials used by the teacher and students are collected. Student products are examined after they have been graded by the teacher, to determine what students actually do in accomplishing a task and how the teacher actually evaluates the products.

Teachers are interviewed formally at the beginning and end of data collection in each class and informally during data collection as needed. Interviews focus on objectives and planning for the observed units and on teacher perceptions of how successful students are with the tasks. Student interviews are also conducted. Generally, six to eight students in each class are selected for interviews focusing on their understanding of the academic work system in the class, their understanding of specific tasks, and their reports of how they go about accomplishing specific tasks.

The first step in analyzing data in a study of academic work consists of mapping out the contents of the observed class periods and identifying tasks in each class. First, all narratives are read and topic lists are produced, specifying for each session the topics and

activities, with time allocations. Next, academic task lists are prepared, specifying for each task the date(s) it is assigned and handed in, the number and dates of sessions involved, the total class time used, notes of closely related or contributing tasks, and whether the task is a major or minor task on the basis of class time use and weight in the accountability system.

Next, a separate analysis of each observed task is undertaken. Using information from the narratives, instructional materials, student products, and the teacher and student interviews, the researcher completes a detailed analysis of each task or, in the case of routine, repetitive tasks, each type of task. The task analysis consists of the following components:

1. a general description or overview of the task and its place in the content unit and work system;

2. all requirements for the task, including any changes in requirements during the time it was worked on;

3. an account of class time use on the task;

4. a description of all the resources and prompts that students appeared to use in completing the task, including a description of content instruction;

5. a general account of "how it went" from initial assignment to turning in of the task, including major events, work flow, student interactions about the task;

6. an analysis of accountability aspects of the task, including teacher's comments about how the task would be graded, how the task and different aspects of the task actually were graded, and grades or credit received by individual students; and

7. an analysis of cognitive operations, both as the teacher intended (according to announcements, interview comments, and instructional materials) and as students appeared to use, in light of information collected about resources, classroom events, student products and performance. Included in this section are summaries of students' reports of how they completed tasks, and their perception of relative difficulty levels of various aspects of the assignment.

An additional step in analysis is to summarize the academic task system in a class, focusing on interrelationships among different tasks and content strands and on the overall strategies that the teacher uses to manage different types of tasks in the classroom.

To date, we have observed and analyzed academic tasks in 10 secondary classrooms as part of the Managing Academic Tasks study. These included four science classes, two at junior and two at senior high level, which have been discussed in several reports (Doyle et al., 1983; Sanford, 1984, 1985). In addition, Doyle and Carter (1984) have reported on a similar study (in English classrooms) that preceded the MAT; and Mitman, Mergendoller, Packer, and Marchman (1984) have used some aspects of the academic task framework in their study of junior high school science instruction.

Some Science Education Research Issues

Content instruction and questioning. One dimension of the academic task framework that suggests a fresh approach to some science education research issues is the way in which content instruction and discussion are treated in the model. In an academic task framework, content presentation, class discussion, and questioning are considered primarily as resources for tasks, not as tasks or as ends in themselves. In this

view, teachers structure students' encounters with content mainly by selecting or designing work for students to do and providing content instruction and other resources to enable students to do that work in particular ways. This view contrasts sharply with the view of teaching as telling. It encourages us to examine relationships between a particular class discussion, the overall task system in the class, and the particular task or tasks for which the discussion is intended to serve as resource.

In their recent view of research on teaching in the natural sciences, White and Tisher (in press) note a steady interest in research on classroom questioning strategies. Many of these studies assume a relationship between classroom discussion and student learning, but research results with regard to effects of higher order questions on student achievement are not at all clear (see reviews by Klinzing, Klinzing-Eurich, & Tisher, 1985; Redfield & Rousseau, 1981; Winne, 1979). Some research has demonstrated that the cognitive levels of student responses do not always match that of teacher questions (Klinzing et al., 1985). Questions about causal relationships, for example, do not always elicit student thinking or response about causal relationships. Research results on this issue vary also, with some very different rates of question-response correspondence being reported. Klinzing, Klinzing-Eurich, and Tisher speculate that question clarity and form probably have something to do with these varying results, and in fact a recent trend in questioning research focuses on form and structure of teacher questions and their influence on students' interpretation and response to questions.

Very little of this research on questioning seems to take into account the task context for the class discussion, and our work with tasks suggests that this oversight may be critical. First, attempting to demonstrate relationships between student learning and teacher questioning while ignoring all the other dimensions of the task system would appear to be a doubtful approach. In addition, it is likely that tasks and task systems influence how students attend to and participate in presentations or discussions, what they focus on, and how they process the information (see Doyle, 1983).

Our study of content instruction in task systems to date (Sanford, 1984) has shown that content presentation and discussions play very different parts in different classroom task systems. For example, in some classes we studied, content instruction took place during long-term tasks or after a task was completed, in preparation for a following task, e.g., discussion of a graded laboratory assignment in preparation for a subsequent test. Students' attention and participation were often higher in such discussions than in discussions under other circumstances. Although I have done no detailed analysis of the issue with our data, I would venture to guess that in focused discussions following higher level tasks, correspondence in cognitive level between teachers' questions and students' responses might tend to be relatively high because of the shared experience of the completed task. Students' expectations about requirements for the following, related task would also need to be considered, however. For example, if students knew that all tests in a class were limited to recall level questions, that expectation might affect how they attended to a higher-level discussion preceding the test.

In another class we have observed, content presentation and discussion appeared to be related only vaguely to students' assignments; tasks rarely required students to use content of these discussions in any way, and there was seldom any discussion of tasks during or after students worked on them. I would postulate that in these two different classes, students interpreted and processed content of classroom discussions very differently. The task and work system contexts of class discussions would seem to be critical aspects to consider in research on questioning.

Testing. Another aspect of the task framework that has perhaps more implications for secondary science education than for some other subject areas is the view that a test is a task. Tests are not simply end-of-topic assessments; science teachers do not give tests primarily to diagnose student learning. They give tests to force students to do something with the content, to work with it or process it in a particular way. Like other tasks, tests determine what students focus on and how they use what they know. Also like other tasks, tests vary in terms of requirements, resources students use in completing them, and accountability.

In some secondary classrooms, as in college level courses, tests may be the dominant or only type of task. In most classes, they are particularly influential tasks because they count more in the classroom accountability system. In one study of junior high classrooms (Mitman et al., 1984), it was noted that tests tended to be the only type of task on which students were held accountable for accuracy and that tests were usually at an even lower cognitive level than more minor tasks. In our own work, we have observed that when a test is both a major task and

a higher level task (i.e., one that requires students to do something other than recall terms, search and match, or apply routine algorithms), it becomes a problematic task for teachers and students to deal with (see Sanford, 1985).

My point in this brief discussion of classroom tests is that exploring further the role that tests play as important classroom tasks could result in better understanding of how teachers' decisions about testing affect student learning. Understanding the complexity of managing tests/tasks may also help us understand the pressures influencing teachers' design and use of tests.

Laboratory activities. Another large body of research in science classes has focused on the role and outcomes of laboratory work or hands-on experience. Reviews (Hofstein & Lunetta, 1982; White & Tisher, in press) have pointed out that much of the research, especially studies comparing laboratory with other forms of instruction, is difficult to interpret because of lack of detail about what students actually do or about teacher-student interaction during lab. Case studies of science laboratory work using the methodology of the MAT study could capture critical details about what students are required to do in lab, what assistance or resources they are given, and aspects of the laboratory work for which they are held accountable. Further, some of the confusion about effects of laboratory work might be addressed by examining how laboratory assignments relate to other tasks and the task system in the class.

Laboratory assignments are interesting tasks to study in that for most students they are novel. They don't look like other class work, and they have relatively high intrinsic interest. This affects

students' understanding of their work and their attitudes about accountability. Students will usually do lab activities regardless of how or whether they are graded.

On the other hand, what students are routinely held accountable for in laboratory work can be important. In one class we studied, there were many laboratory activities that at first glance would seem to require higher level thinking of students. However, the teacher consistently held students accountable only for the form or format of their lab reports. Students were never graded or corrected on any comprehension level work. Any response, even an inaccurate or nonsensical one, was often accepted for lab work, and the assignments were never discussed in class. Students' lab reports showed very little attempt at higher cognitive aspects of lab problems. Repeated observations and careful analysis of laboratory tasks in this class resulted in a very different picture of students' work experiences than would result from limited observation or interviews with the teacher.

Curriculum implementation. Another concern of science education that might be informed by research on academic tasks is curriculum implementation and evaluation. Two decades of efforts to evaluate and compare science programs and curriculum innovations have demonstrated that sensible comparison is impossible without detailed attention to description of the curriculum as it is inacted in different classrooms. Gallagher's (1967) study of implementation of BSCS curriculum was an early study underscoring this fact. White and Tisher (in press) note that science curriculum research has shifted toward collection and reporting of more data on classroom processes and analysis of content.

Our studies of academic work suggest that to assess curriculum implementation we must indeed look very closely at teaching. In addition, the academic task framework calls attention to details that appear to be critical in describing the "curriculum in place." Curriculum evaluations may be incomplete, perhaps misleading, if they ignore what appears to be such important aspects of classroom task systems as accountability, relationships among tasks and content instruction episodes, strategies teachers use in managing tasks, and detailed information about resources provided students as they work.

Case studies of class work such as the MAT are time consuming and expensive to conduct. They cannot possibly be conducted on a large scale to sample implementation of a curriculum project in many sites. However, on a limited basis case studies of tasks could inform and complement other kinds of data collection, such as surveys, student and teacher questionnaires, and less intensive qualitative studies.

Doyle (1983) has also argued that understanding classroom task environments and the pressures created by those environments will contribute much to understanding the problems of implementing changes in a curriculum. Findings (Doyle & Carter, 1984; Sanford, 1985) about the great complexity that teachers face in conducting higher level tasks in classrooms certainly illustrate some of the potential problems in implementing science curriculum changes.

Summary

In summary, this article attempts to provide a partial answer to the question, "What might be learned by studying academic tasks in science classrooms," by suggesting several applications of the academic

task framework to rethinking and study of some enduring problems and issues in science education.

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